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DOC 01 REV DATE 29 MAY 1980 BY 018323
ORIG COMP 56 OPI 51 TYPE 02
ORIG CLASS S PAGES 32 REV CLASS C
JUST 22 NEXT REV 2010 AUTH: NR 40-2

SUMMARY REPORT

on

TASK ORDER NO. D

April 30, 1957

SECRET CONFIDENTIAL

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SUMMARY REPORT

on

TASK ORDER NO. D

April 30, 1957

INTRODUCTION

This summary report describes the work performed under Task Order No. D from May 29, 1956, through April 30, 1957, on the development of a rectangular-cross-sectioned watertight container.

A detailed description of the design specifications for the container of interest, the development of the prototype design, fabrication of the prototypes, and the tests performed to evaluate the design are described in this report.

SUMMARY

The principal problems involved in this research program concerned the development of a watertight closure for a 4- x 9-inch rectangular opening, and the development of a lightweight, corrosion-resistant shell, 4 x 9 inches in cross section and 50 inches long, that would withstand an external hydrostatic pressure of 6 feet of water (2.6 psi).

Preliminary tests were made with rectangular closure parts to determine the sealing effectiveness of an O-ring under ideal conditions. Sealing tests were then made with 1/16-inch-thick wall sections to simulate lightweight construction. Both types of tests showed that an O-ring seal would be satisfactory for the proposed rectangular closure.

After completing the preliminary closure tests, we studied various methods of fabricating stainless steel closure parts that would eliminate

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precision machining. It was decided that satisfactory parts could be obtained by hydroforming. The necessary hydroformed parts were ordered, assembled, and tested.

In conjunction with the closure development, a design study was made of latches for securing the lid. The selected latch was a toggle type, permanently attached to the lid to prevent loss. The latch also served as a handle to aid in removing the lid during opening of the container.

To investigate different types of shell construction, experimental shell panels of stainless steel were tested with a vacuum panel-testing unit. These tests showed that the minimum material thickness that could be used for the shell was 24 gage (0.024 inch) and that material of this thickness had to be reinforced by dimpling or by using attached dimpled strips.

A number of experimental container shells were then fabricated from stainless steel and tested. The most satisfactory type of shell construction involved a 24-gage shell that had been reinforced with attached dimpled strips. However, because a shell reinforced in this manner weighed as much as an unreinforced 22-gage (0.030 inch) shell, an experimental shell of the latter type was fabricated and tested. This shell met the specified requirements and was cheaper. Consequently, it was selected for use in the prototype.

Following the shell development work, three prototype containers were fabricated from stainless steel and tested. The results showed the design to be satisfactory. The containers withstood a static loading force of 1,350 pounds without buckling and did not show any permanent deformation

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until subjected to a simulated hydrostatic pressure of 14.5 feet of water (6.5 psi). No leakage was visibly detectable at a pressure equivalent to 6 feet of water. These results were particularly satisfactory because they were obtained on a container that weighed 15 pounds, although at the beginning of the program, we were doubtful that we could achieve even the desired weight of 20 pounds.

The prototype containers were discussed with the Sponsor early in May. In accordance with decisions made at that time, two general-services task programs have been proposed to permit making desirable modifications and some additional tests.

ENGINEERING ACTIVITY

The engineering activity performed to accomplish the objective of this program included the design of the container, and the evaluation of the suitability of the design on the basis of strength and watertightness.

Design Specifications

The design specifications indicated that the desired container should:

(1) Be approximately 4 x 9 inches in cross section (inside) and have a minimum inside clear length of 50 inches.

(2) Be easily opened and closed.

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(3) Be watertight when immersed at a depth of approximately 6 feet of water.

(4) Be provided with means for carrying (straps, handles, etc.).

(5) Be provided with an effective leak-proof closure head.

(6) Prevent corrosion of materials stored in the container for long periods of underground burial.

(7) Weigh no more than 20 pounds.

(8) Be constructed of Type 316 stainless steel.

(9) Be rigid enough to support the weight of 11 other fully loaded containers stacked on top of it (total dead weight of approximately 1,350 pounds).

Container Design

The container was considered to be composed of two parts, namely, the closure and the shell. In subsequent sections of this report, the activity leading to the development of the prototype closure, closure latch, and shell is discussed in detail.

Closure Development

The initial work was directed toward the design of an adequate seal for the closure. The development of a closure for the cylindrical container prepared under Research Order No. 16 had shown that O-rings had many attractive properties. However, the effectiveness of O-rings in sealing a rectangular opening was unknown. Consequently, a study was undertaken to evaluate the effectiveness of an O-ring for sealing the rectangular-cross-sectioned opening of the proposed container.

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Figure 1 shows the first seal-testing unit devised for this O-ring sealing study. The flange and lid sections were machined with heavy sections, to prevent any deformation of the metal surfaces involved in sealing, and care was taken to maintain accurate dimensions. Leak testing of this unit by immersion in water showed that an O-ring would seal the rectangular opening under these ideal conditions.

Because of the weight limitation for the proposed container, it was necessary to determine the effectiveness of an O-ring in sealing thin-walled closure components. Figure 2 shows the seal-testing unit after the flange- and lid-section walls had been machined to a thickness of 1/16 inch. This modified unit also sealed satisfactorily with an O-ring in differential-pressure leak tests.

Following the successful conclusion of the sealing tests, it was necessary to find a production method of fabricating thin-walled stainless steel closure parts that would eliminate the precision-machining operations used on the experimental units. A survey showed that hydroforming the parts from sheet material would be the most satisfactory method.

Drawings for the various closure parts were then prepared, and an order for these parts was placed with a commercial hydroforming contractor.

After receiving the formed parts from the fabricator, we trimmed and checked them for dimensions. Figures 3 and 4 show the parts in the as-formed and in the trimmed stages, respectively. A dimensional check showed that the trimmed parts were within satisfactory limits.

A preliminary test was then made to check the sealing ability of an O-ring with these formed parts. For this test, the unit shown in Figure 5

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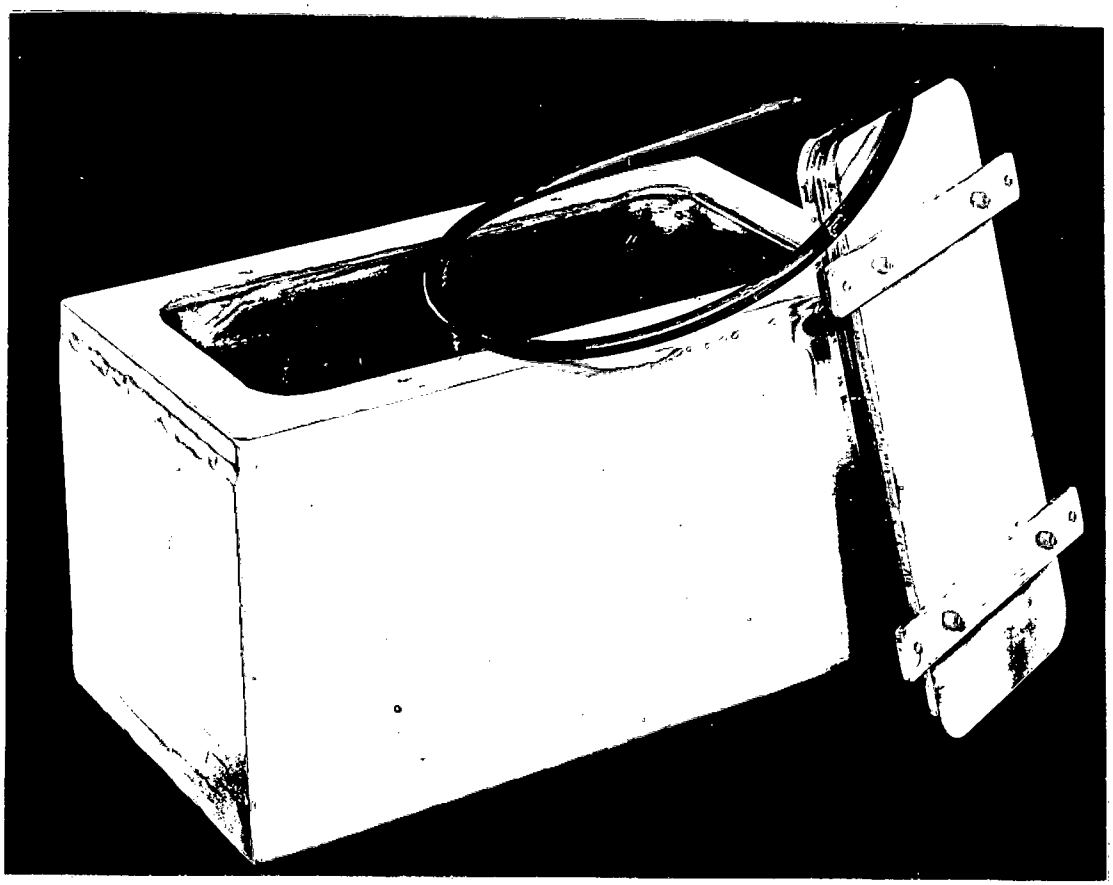

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Figure 1. Heavy-Wall Seal-Testing Unit

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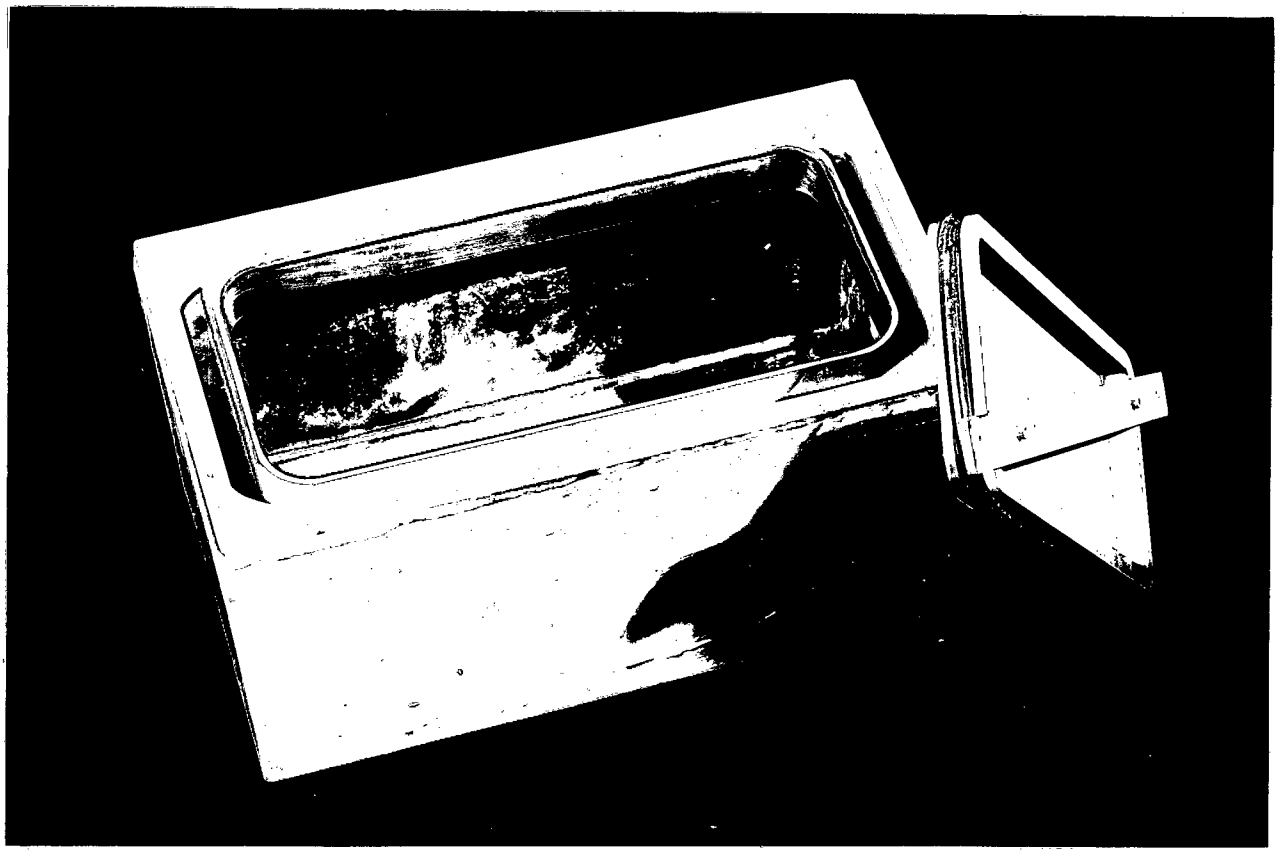

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Figure 2. Thin-Wall Seal-Testing Unit

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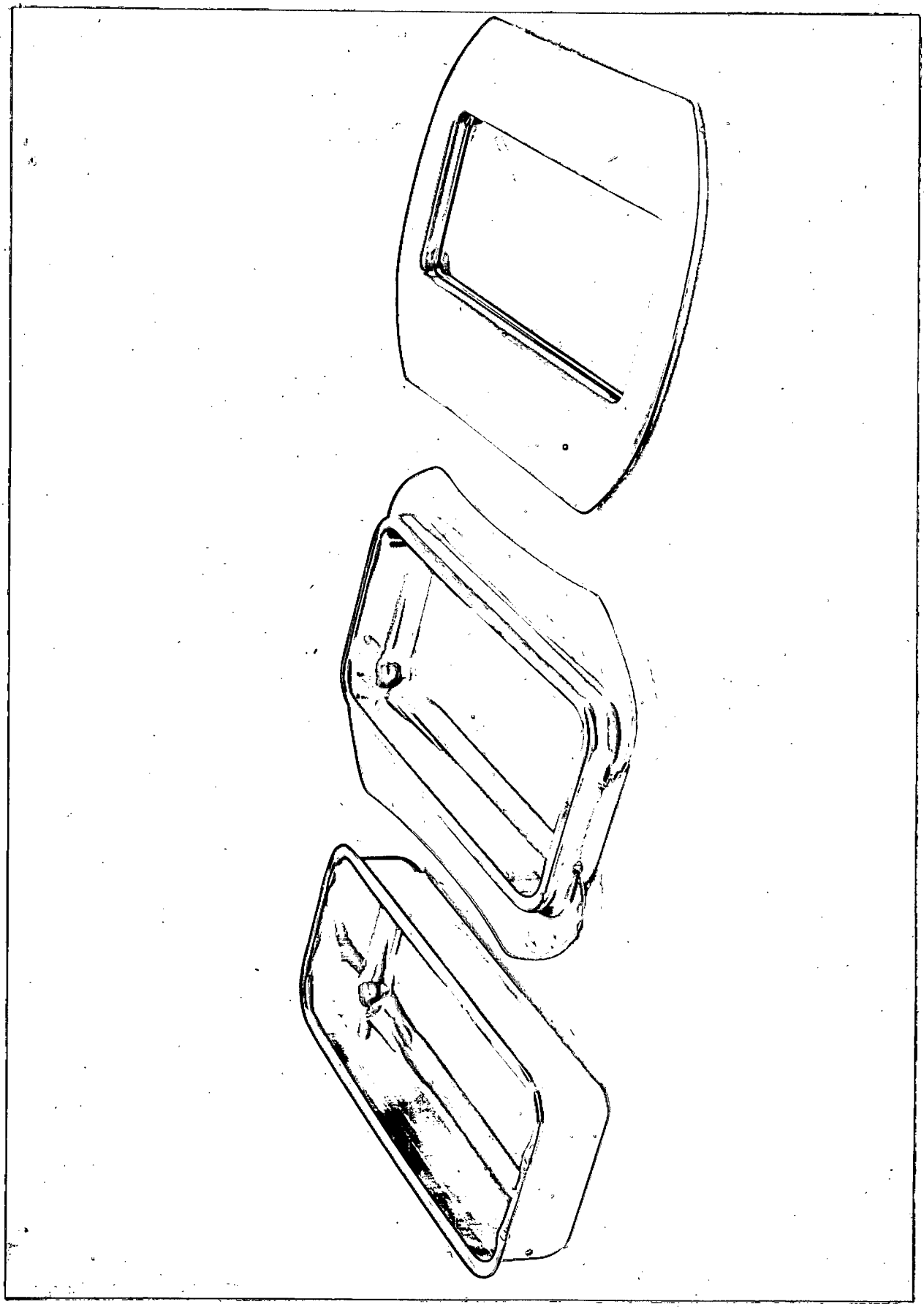

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Figure 3. Hydroformed Closure Parts - As Formed

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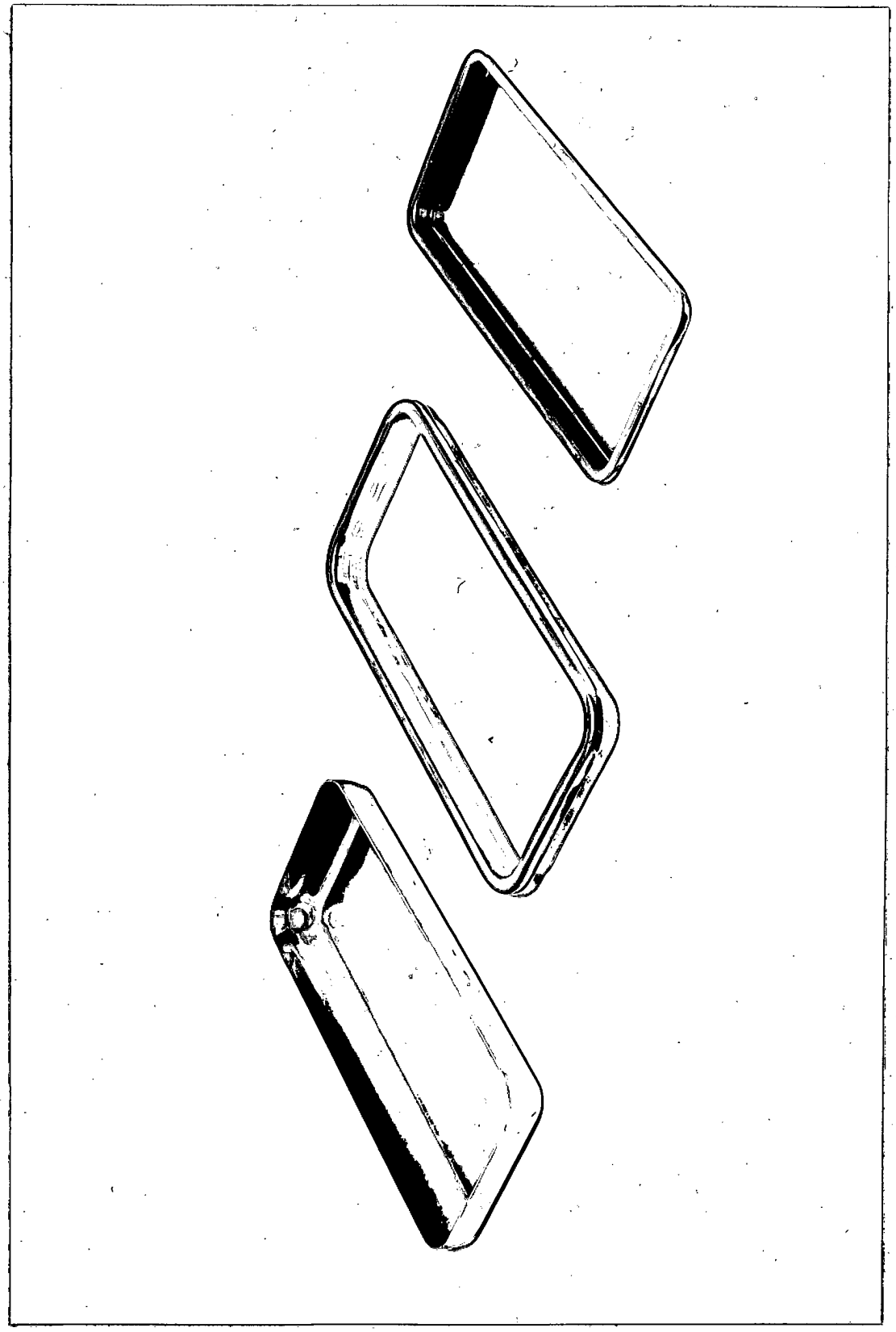

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Figure 4. Hydroformed Closure Parts - Trimmed

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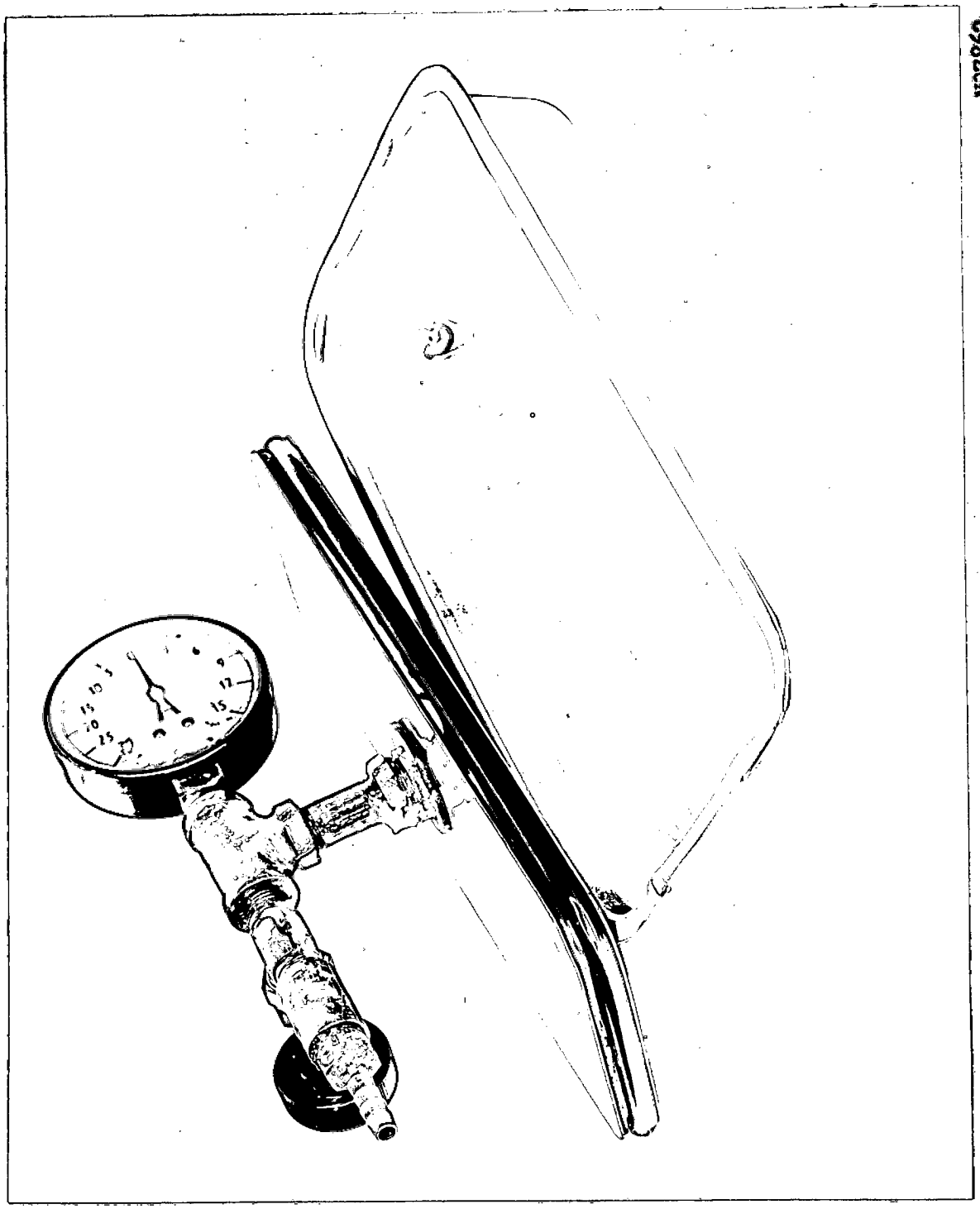

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Figure 5. Seal-Test Unit With Hydroformed Parts

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was constructed. Essentially, this test unit consisted of a lid assembly and a formed box; the latter was substituted for the proposed flange and container assembly. Because the formed-box portion of the test unit did not have a completely turned-over flange, pressure applied to the unit caused the center portions of the long (9-inch) sides to bow and they would not seal. Further sealing tests were discontinued until a full-size experimental container with stronger flanges could be fabricated.

In the preparation of a full-size experimental container, a heavy steel insert was used to minimize warping of the flange section of the container during welding. Although the dimensions were not affected, the weld penetrated the 20-gage flange material and roughened the sealing surfaces. These surfaces were ground and filled with solder, to obtain a smooth sealing surface for leak testing. To eliminate this problem, we decided to use heavier gage material in the flange, and new flanges made from 16-gage material were ordered for use later in the program.

Helium leak testing of this experimental container showed that the sealing achieved was satisfactory.

Closure Latch Design

In conjunction with the closure development work, a design study was made of latches to hold the lid on the container. Figure 6 shows cross-section views of six experimental latches. These were either spring-snap or sliding types. If actually used on a container, each of these, except for latches Nos. 2 and 4 (Figure 6), could be lost because it was not designed

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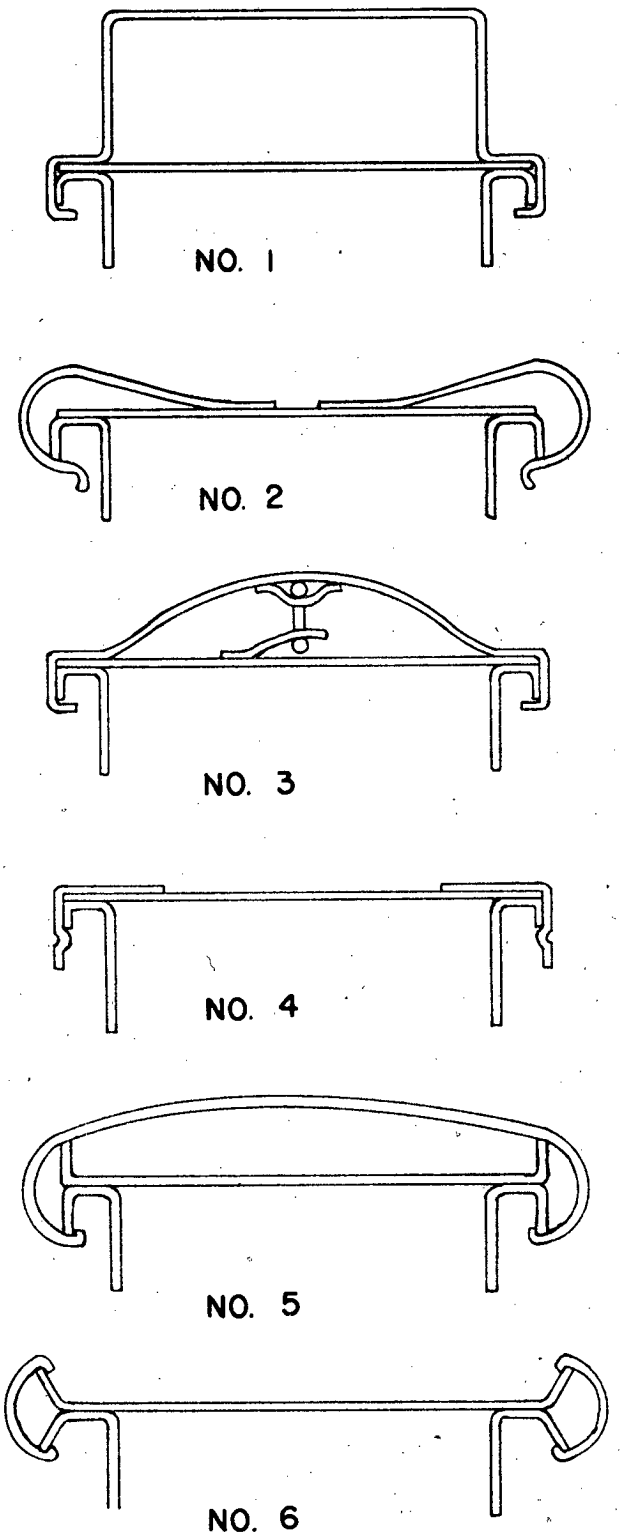

FIGURE 6. EXPERIMENTAL LATCH DESIGNS

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to be attached permanently to the lid. Some other disadvantages of these designs were the possibility of the sliding type being stuck by dirt or of the snap type being accidentally bumped open.

The latch design which was finally accepted was a toggle-type latch, shown in Figure 7 in the closed position. The features of this latch eliminated the disadvantages of possible sticking and accidental opening; in addition, this latch is designed to be permanently attached to the lid. The latch also serves as a handle, to facilitate removing the lid from the container, as shown in Figure 8.

Shell Development

The primary considerations in the development of the shell for the proposed container were those of strength and weight. It was specified that the proposed container was to withstand an external hydrostatic pressure of approximately 6 feet of water and a dead load weight of approximately 1,350 pounds without permanent deformation. Also, the container was to be made of Type 316 stainless steel and have a maximum weight of 20 pounds.

Two designs were considered for maximum strength with minimum weight. The first achieved added strength from a dimpled shell. The second used an internal reinforcing frame to support a relatively thin shell.

A vacuum panel-test unit, shown in Figure 9, was used to determine the most effective shell construction. Different types of dimpled and reinforced panel designs were tested in this unit. Table 1 shows the test-panel designs, and describes the materials and the pertinent data obtained

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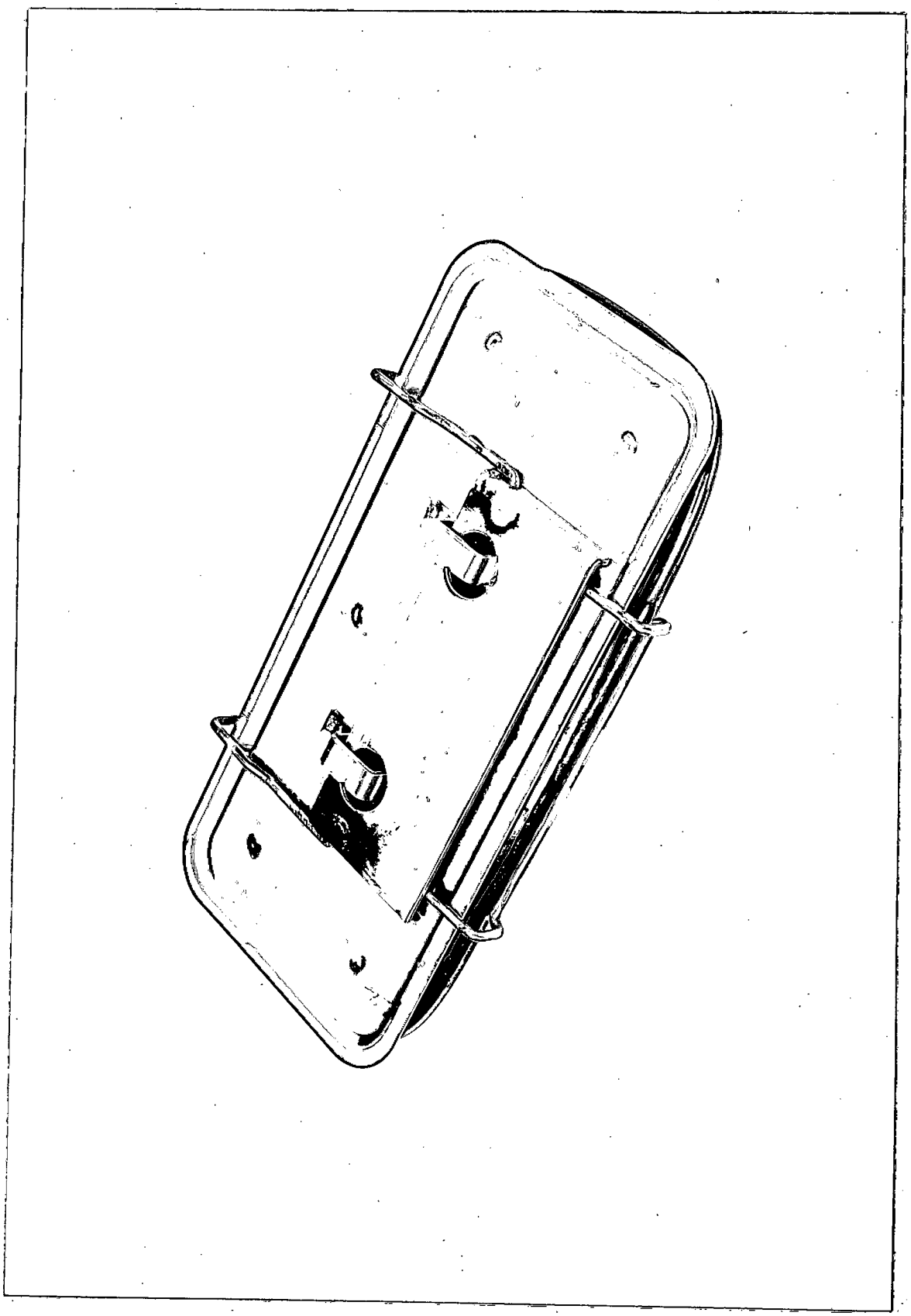

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Figure 7. Lid With Toggle-Type Latch in Closed Position

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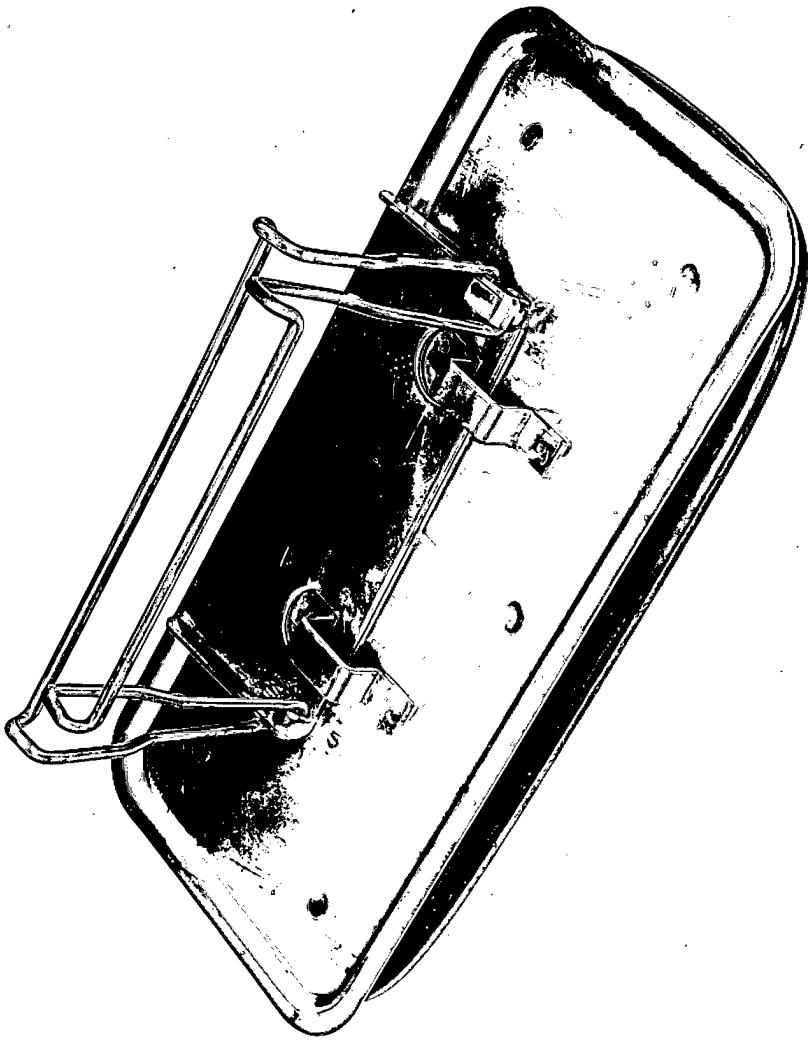

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Figure 8. Lid With Toggle-Type Latch in Open Position

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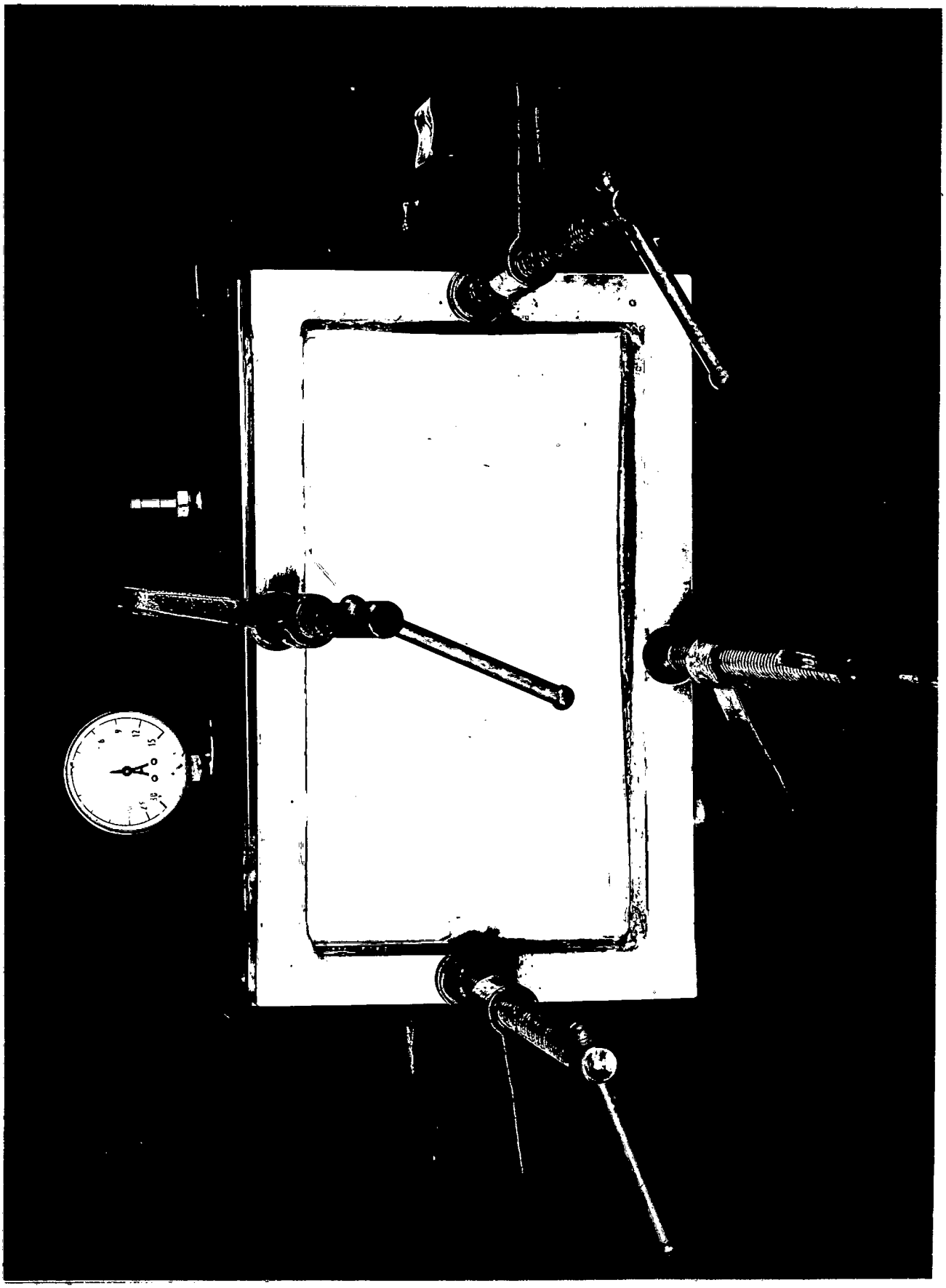

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Figure 9. Vacuum Panel-Testing Unit, With Test Panel in Position

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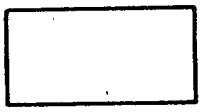
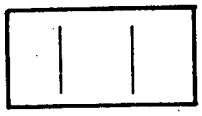
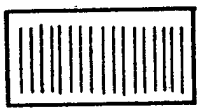
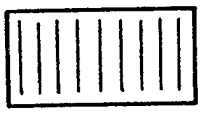
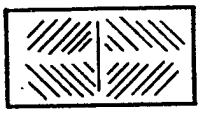
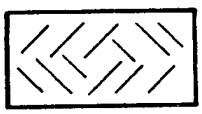
TABLE 1. DATA OBTAINED FROM PANEL TESTING

Panel	Description	Max. Deflection at 6 ft of Water, inch	Panel Weight, lbs per sq ft
	26 gage plain	0.204	0.788
	24 gage plain	0.156	1.050
	26 gage beaded; beads 6 inches on centerline	0.204	0.788
	No. 1; 24 gage beaded as shown	0.094	1.05
	No. 2; 24 gage beaded as shown - beads 5/8 inch on centerline	0.094	1.05
	No. 3; 24 gage beaded as shown - beads 1-1/4 inches on centerline	0.094	1.05
	No. 4; 24 gage beaded as shown - beads 2-1/2 inches on centerline	0.125	1.05
	No. 5; 24 gage beaded as shown	0.094	1.05
	No. 6; 24 gage beaded as shown (also see Figure 10)	0.078	1.05
	No. 7; 24 gage beaded as shown	0.094	1.05

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from the tests. The size of panel used for the tests was 7 x 13 inches; in each case, the bead radius was 1/2 inch and the bead depth 3/32 inch.

The results of the panel tests showed that, of the two thicknesses of material evaluated, 24 gage (0.024 inch) was the minimum thickness of metal that could be used for the shell, because it deflected less than the other. The tests also indicated that the No. 6 beaded panel and the panel reinforced with spotwelded, beaded strips, shown in Figure 10, generally deflected the least, with one exception, namely, the angle- or channel-reinforced panels; however, the latter were eliminated from further consideration because the use of those types of construction would increase the weight and over-all size of the proposed container.

In order to supplement the panel-testing program, our Applied Mechanics Division was requested to determine theoretically, if possible, the minimum weight of dimpled shell and of reinforced shell that would provide the strength required for the proposed container. The analysis was made, and, as a result, it was concluded that pertinent stress calculations involve too many assumptions to yield reliable answers. The performance of experimental tests on shells of similar geometry was considered to be the only accurate method of determining the optimum construction. This was especially true in the design and location of stiffening devices.

Since enough panels had been tested to provide a good basis for comparison of the stiffness provided by the various dimpling and reinforcing designs, a test program using full-size containers was undertaken.

Three containers were constructed for the first series of tests. One, shown in Figure 11, consisted of a plain 24-gage stainless steel shell

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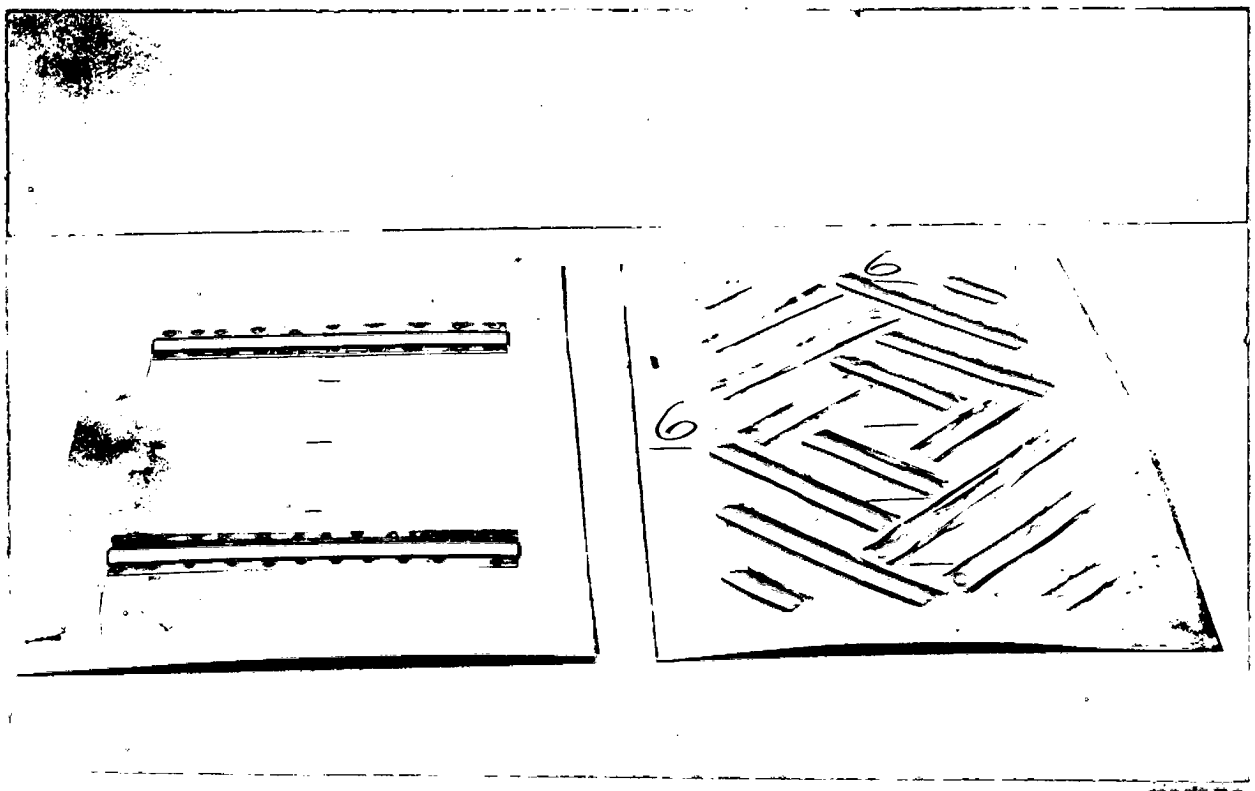

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Figure 10. Two Types of Beaded Panels Showing the Least Deflection During Panel Testing

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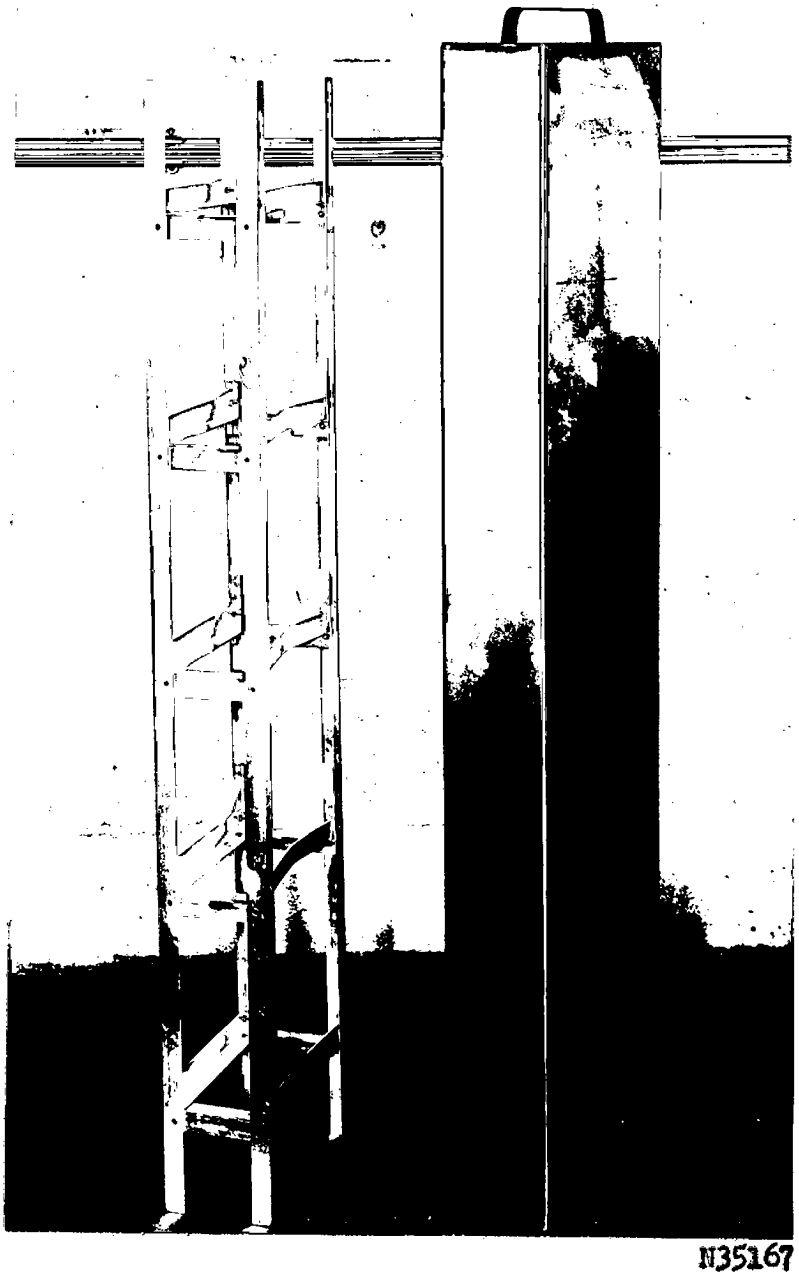

Figure 11. Test Container With Aluminum Frame (24-gage stainless steel)

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with an internal aluminum-angle frame for support. This was constructed so that the internal dimensions of the framework were the required 4- x 9-inch dimensions. The remaining two containers, shown in Figure 12, were fabricated from 24-gage stainless steel sheet with a dimple pattern similar to that used by the Sponsor on the small rectangular-cross-sectioned (7 x 9 x 16-1/2) container. In addition, 24-gage reinforcing strips were soldered to the sides of one of the dimpled containers. Tests with these containers showed that only the reinforced dimpled container would withstand the required external hydrostatic pressure of 6 feet of water without permanent deformation.

Two questions arose as a result of these tests. First, would it be possible to make a container sufficiently strong by welding reinforcing strips to an undimpled shell? Second, since calculations showed that the weight of the 24-gage stainless steel container with a dimpled shell and reinforcing strips was equivalent to that of a 22-gage stainless steel container with an undimpled shell and no reinforcing strips, would a 22-gage container be strong enough?

To determine the answer to these questions, we fabricated the two experimental containers shown in Figure 13. One was made of 24-gage stainless steel with reinforcing strips attached to an undimpled shell. The other consisted of 22-gage stainless steel without any dimpling or reinforcing strips. Both units weighed approximately 13-3/4 pounds and both withstood the required pressure of 6 feet of water.

As shown in Figure 13, the 22-gage container was constructed with relatively sharp corner radii in order to expedite fabrication. There was

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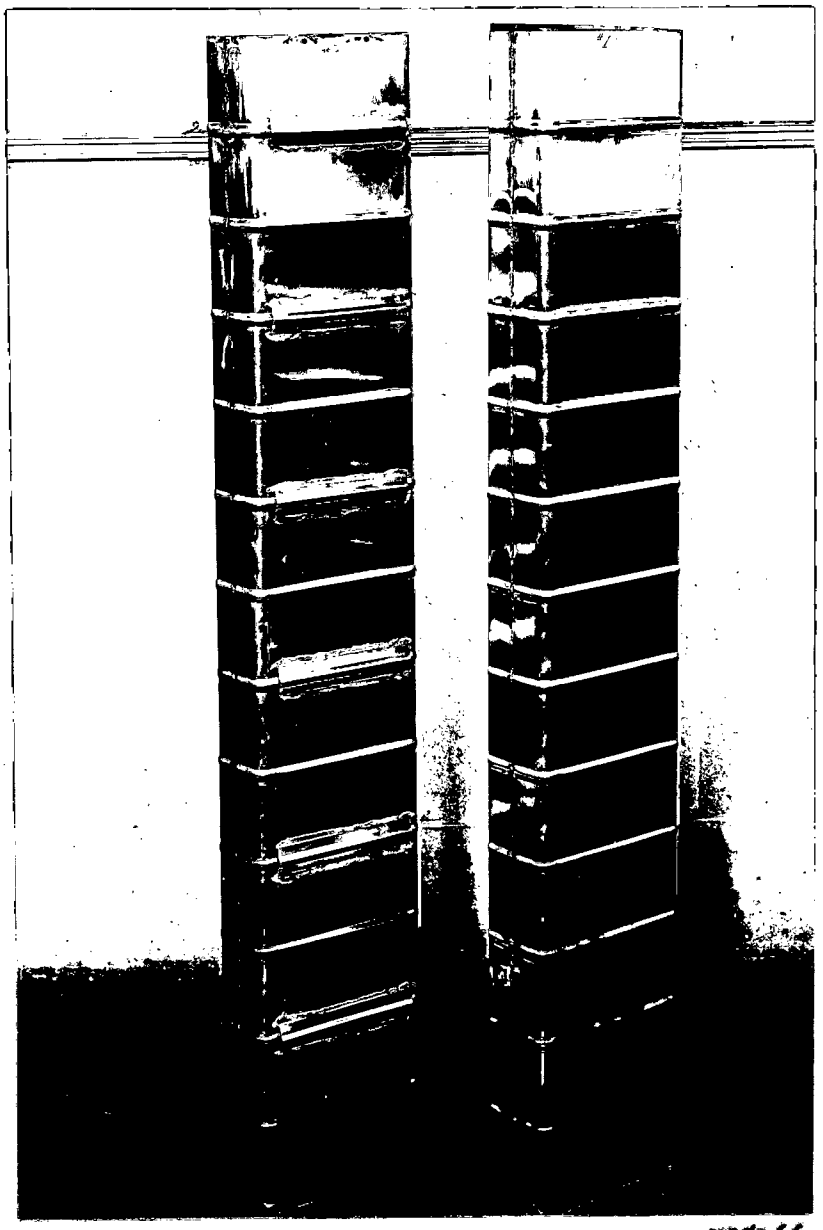

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Figure 12. Dimpled Container Shells, With and Without Reinforcing Strips (24-gage stainless steel)

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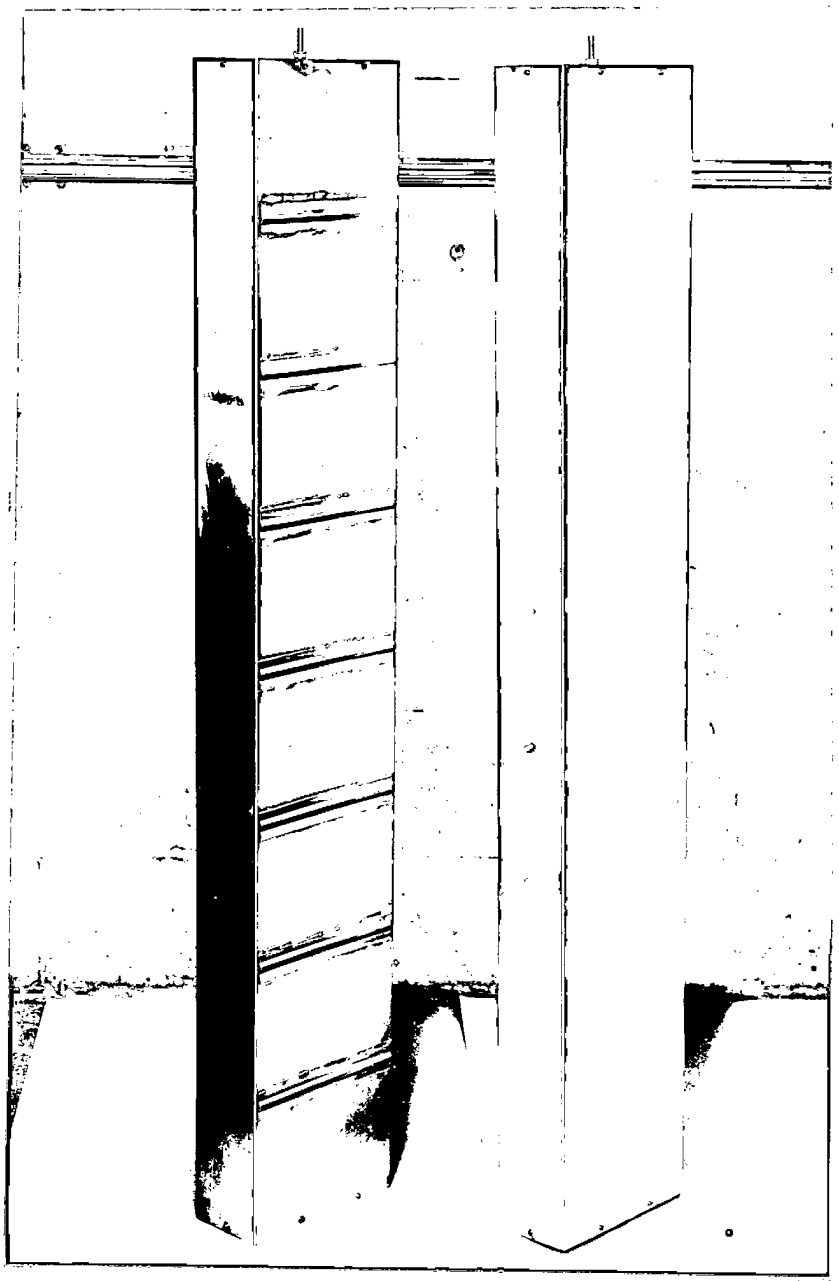

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Figure 13. Experimental Containers With (Left) 24-Gage Stainless Steel Shell, Undimpled and Reinforced, and (Right) 22-Gage Stainless Steel Plain Shell

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some doubt, however, that this container would meet the strength requirements if the corner radii were enlarged to 5/8 inch, as required by the design of closure parts. Therefore, a container was fabricated from 22-gage stainless steel with 5/8-inch corner radii. Tests with this unit proved that the design was satisfactory and a complete experimental container was fabricated. Figure 14 shows the test container with 5/8-inch corner radii, and the complete experimental container which was tested for watertightness and strength and found to be satisfactory.

Prototype Fabrication

As a result of the design investigations and testing programs, a rectangular-cross-sectioned container design was finalized and three prototype containers were fabricated.

Figure 15 gives the principal dimensions and cross-section detail of the design. Figure 16 shows an assembled container.

Each assembled container weighed 15 pounds. The container shell consisted of a rectangular-cross-sectioned tube which was fabricated from 22-gage sheet material with one longitudinal seam. A hydroformed 20-gage sheet-metal bottom was welded to one end of the tube and a 16-gage sheet-metal flange section was welded to the other end. The handles were made from 5/16-inch-diameter rods, which fitted into 16-gage straps welded to the 4-inch, seamed side of the container.

A continuous circular-cross-sectioned O-ring (AN-6277-68, Specification MIL-P-5516) was used in the O-ring groove in the fabricated sheet-metal

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Figure 14. 22-Gage Stainless Steel Test Container With 5/8-Inch Corner Radii (Right) and Complete Experimental Container (Left)

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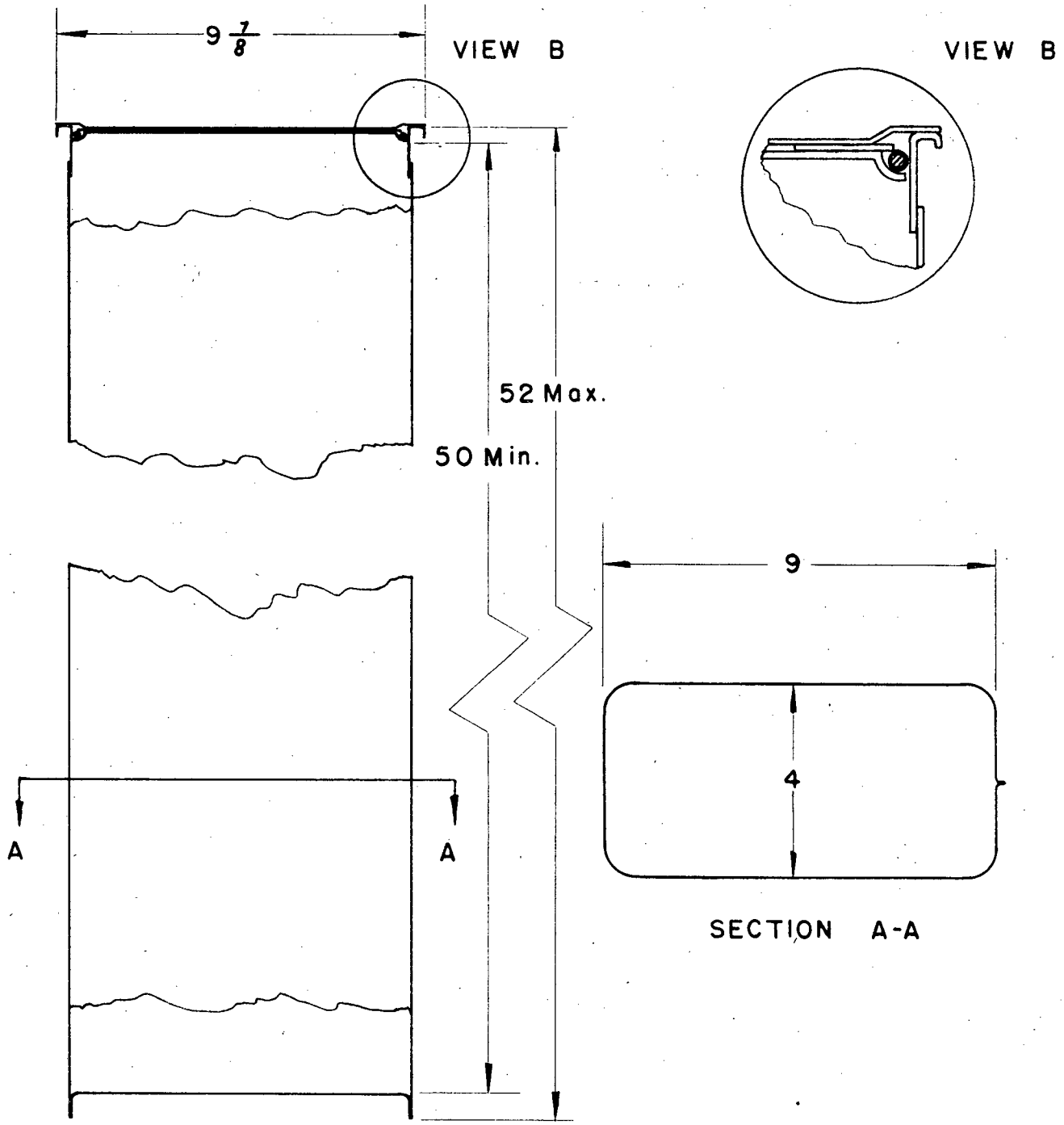

FIGURE 15. PRINCIPAL DIMENSIONS OF THE PROTOTYPE CONTAINER

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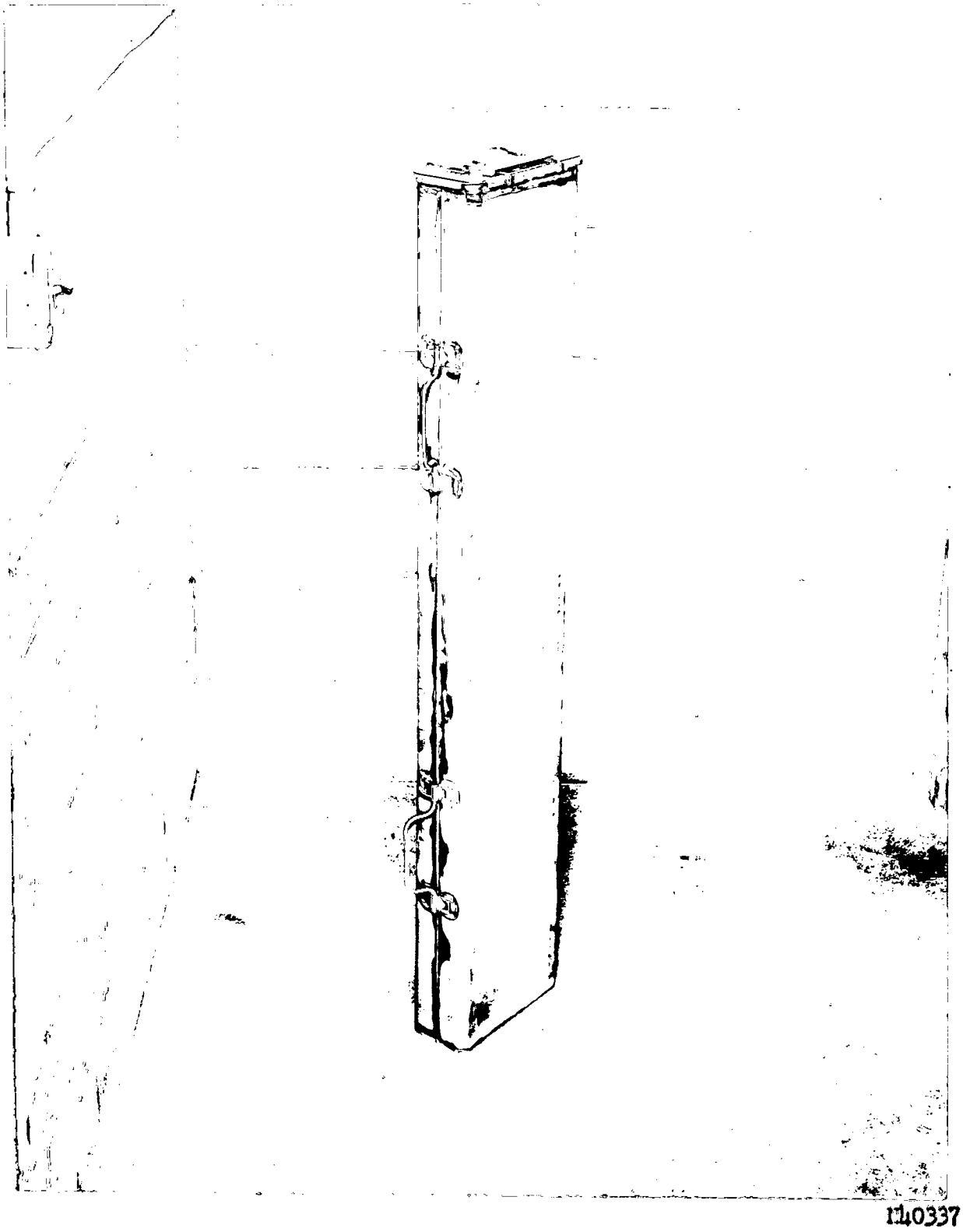

Figure 16. Assembled Prototype Container

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lid. The lid was made of two formed parts and one flat part joined together by spotwelding. The latch was permanently attached to the lid by formed sheet-metal straps that were spotwelded to the lid (see Figures 7 and 8). The latch included two formed clamping members made from 1/8-inch-diameter rod, which were installed in the short sides of the formed channel-shaped sheet-metal toggle member.

All of the sheet metal used in the prototype container and the handle rod stock were Type 316 stainless steel. The clamping members of the latch were made from Type 310 rod. With the exception of the spotwelding, all of the welding was done with Type 310 electrodes using the Heliarc method.

Container Testing

Two testing procedures were used in the final check of the prototype containers. They were the helium leak test and a dead-weight loading test.

In leak testing the container, we first connected the unit to a helium mass spectrometer. A vacuum was then drawn in the container that was equivalent to a hydrostatic pressure of 6 feet of water. A probe emitting a jet of helium was then used to scan the entire container. As a result of scanning all of the welds and the sealing areas of the container, any small leak in either would have been detected and recorded by the mass spectrometer.

In addition, this test provided a check on the strength of the container under 6 feet of water.

The second test used on the prototype containers was the dead-weight load test. This test was devised to simulate the rigors of storage stacking

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of fully loaded containers, 12 high. With this stacking arrangement, a load of approximately 1,350 pounds would be imposed on the bottom container. For this test, a container was placed on the floor horizontally on the 9-inch side. A board large enough to contact the entire side of the container was then placed on top of it and loaded with weights equalling 1,350 pounds. After this load was removed, the container was checked, and no deformation was noted.

In addition to the above two tests used on all three of the prototype units, one unit was checked at the request of the Sponsor, to determine what depth of water would cause permanent deformation of the container shell. At a depth of 14.5 (6.5 psi) feet of water, permanent deformation resulted. However, no leakage was detected around the O-ring seal at this pressure.

FUTURE WORK

During May, the Sponsor examined the three prototype containers and expressed satisfaction with the results of the work. Some modifications of the design and the possibility of preparing approximately 50 additional prototype containers were discussed.

As a result, it was decided that two proposals should be prepared covering the investigation of selected, minor modifications to this container under Work Orders of the general-services task. These were prepared and transmitted on May 14, 1957. It is anticipated currently that, after the modification effort is concluded, consideration will be given to the preparation of approximately 50 prototype containers and also to an investigation of the molding of an O-ring for the rectangular closure of this type of container.

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